Resource & Environmental Consultants Ltd

UKAS TESTING 2082

MONITORING OF EMISSIONS FROM THE INKJET MANUFACTURING PROCESS VENTS

7-9 APRIL 2014

Prepared for Xaarjet Ltd

REC Report 71836p1r0

Issued: 14 May, 2014

REC Air Quality

GREEN ACHIEVER™

safecontractor™ APPROVED

Prepared for:

Xaarjet Ltd
1 Hurricane Close
Ermine Business Park
Huntingdon
PE29 6XX

Prepared by:

REC Ltd
Unit 19 Bordesley Trading Estate
Bordesley Green Road
Birmingham
B8 1BZ
Tel : 0121 326 7007
Fax : 0121 328 1689
E-mail : sales@recltd.co.uk
Web : www.recltd.co.uk

Issued : 14 May, 2014
Reference : 71836p1r0

Prepared by : _____
A Wrynne, Env. Technician
MM08 921, MCERTS Level 2

Reviewed by : _____
P Furmston, Director

CONTENTS **Page No.**

FIGURES (7 x Additional Pages)

1 Total VOC Emission Data Summary, LEV 1, Xaarjet Ltd 9/04/14 (data expressed at 273K, 101.3kPa, without correction for water vapour & oxygen).
2 Total VOC Emission Data Summary, LEV 2, Xaarjet Ltd 9/04/14 (data expressed at 273K, 101.3kPa, without correction for water vapour & oxygen).
3 Total VOC Emission Data Summary, LEV 9, Xaajet Ltd 7/04/14 (data expressed at 273K, 101.3kPa, without correction for water vapour & oxygen).
4 Total VOC Emission Data Summary, LEV 13, Xaarjet Ltd 8/04/14 (data expressed at 273K, 101.3kPa, without correction for water vapour & oxygen).
5 Total VOC Emission Data Summary, LEV 14, Xaarjet Ltd 8/04/14 (data expressed at 273K, 101.3kPa, without correction for water vapour & oxygen).
6 Total VOC Emission Data Summary, LEV 17, Xaarjet Ltd 8/04/14 (data expressed at 273K, 101.3kPa, without correction for water vapour & oxygen).
7 Total VOC Emission Data Summary, LEV 19, Xaarjet Ltd 7/04/14 (data expressed at 273K, 101.3kPa, without correction for water vapour & oxygen).

TABLES (9 x Additional Pages)

1 Flow Data
2 Total VOC Emission Data Summary – LEVs: 1, 2, 9, 13, 14, 17 & 19.
3 Target VOC Emission Data Summary – LEVs: 1, 2, 9, 13, 14, 17 & 19.
4 Fluorine Emission Data Summary – LEVs 3 & 4
5 HNO_3, HCL, HF & H_2S0_4 Emission Data summary – LEVs 6, 7, 15 & 19.
6 Nickel Emission Data Summary – LEVs 6
7 Lead & Zirconium Emission data summary – LEVs 8, 10 & 18.

APPENDICES

1 Certificate of Analysis (4 x Additional Pages)
2 Diagrams of Sampling Points (3 x Additional Pages)
3 Calculations (1 x Additional Page)

EXECUTIVE SUMMARY

Resource & Environmental Consultants (REC) Ltd was commissioned by Xaarjet Ltd to monitor emissions of pollutants released from the Inkjet manufacturing process at their site in Huntingdon. In accordance with the requirements of their site permit and internal requirements, monitoring has been undertaken for the following pollutants:-

- Acid gases including Hydrogen Chloride (HCl), Hydrogen Fluoride(HF), Nitric acid(HNO_3) & Sulphuric Acid (H_2S0_4)
- Fluorine
- Nickel , Lead & Zirconium
- Total Volatile Organic Compounds (VOCs) expressed as Carbon (C)
- Target VOCs, including Isopropyl alcohol & Acetone

The following results were obtained from the emission monitoring survey and are compared with the current permit limit:-

Species	Emission Source						UKAS Status	Permit Limit (mg/Nm^3)
	LEV 1	LEV 2	LEV 3	LEV 4	LEV 6	LEV 7		
	Emission Concentration in mg/m^3							
Total VOCs	82.0	10.6	-	-	-	--	A	75
Isopropanol	30.2	2.8	-	-	-	--	B	None Set
Acetone	3.7	3.8	-	-	-	--	B	None Set
Hydrogen Chloride	-	-	-	-	0.03	-	E	None Set
Hydrogen Fluoride	-	-	-	-	>0.01	-	E	None Set
Nitric Acid	-	-	-	-	1.3	0.06	E	None Set
Sulphuric Acid	-	-	-	-	>0.07	-	E	None Set
Nickel	-	-	-	-	>0.01	-	E	None Set
Fluorine	-	-	<0.1	<0.1	-	--	E	None Set

NOTE 1: All data are expressed in mg/Nm^3 at 273K, 101.3kPa, without correction for moisture and oxygen content unless otherwise stated.
NOTE: UKAS Status:- (A) REC Ltd accredited for sampling and analysis. (B) REC Ltd accredited for sampling only, UKAS accredited analysis conducted by SAL Ltd. (C) REC Ltd accredited for sampling, sub-contracted analysis not UKAS accredited (D) REC Ltd not accredited for sampling, UKAS accredited analysis conducted by SAL Ltd. (E) REC Ltd not accredited for sampling, sub-contracted analysis not UKAS accredited.

EXECUTIVE SUMMARY (CONTINUED)

Species	Emission Source									UKAS Status	Permit Limit (mg/Nm^3)
	LEV 8	LEV 9	LEV 10	LEV 13	LEV 14	LEV 15	LEV 17	LEV 18	LEV 19		
Total VOCs	-	93.8	-	11.4	6.7	-	10.5	-	10.0	A	75
Isopropanol	-	61.9	-	3	3.2	-	5.3	-	<2.5	B	None Set
Acetone	-	54.8	-	15.7	5.2	-	5.7	-	3.0	B	None Set
Lead	>0.01	-	>0.01	-	-	-	-	0.01	-	E	None Set
Nickel	-	-	-	-	-	-	-	-	-	E	None Set
Zirconium	>0.01	-	>0.01	-	-	-	-	>0.01	-	E	None Set
Fluorine	-	-	-	-	-	-	-	-	-	E	None Set
Nitric acid	-	-	-	-	-	<0.01	-	-	<0.01	E	None Set

NOTE 1: All data are expressed in mg/Nm^3 at 273K, 101.3kPa, without correction for moisture and oxygen content unless otherwise stated.
NOTE: UKAS Status:- (A) REC Ltd accredited for sampling and analysis. (B) REC Ltd accredited for sampling only, UKAS accredited analysis conducted by SAL Ltd. (C) REC Ltd accredited for sampling, sub-contracted analysis not UKAS accredited (D) REC Ltd not accredited for sampling, UKAS accredited analysis conducted by SAL Ltd. (E) REC Ltd not accredited for sampling, sub-contracted analysis not UKAS accredited.

INTRODUCTION

1.1 Background

Xaarjet Ltd commissioned REC Ltd to conduct an emission monitoring survey on the Inkjet manufacturing process vents at their site in Huntingdon.

The process involves the use of solvents and acid based solutions in the production and cleaning of inkjet cartridges.

Only total VOC emissions are actually covered in the site permit but additional internal information was required on potential releases of other contaminants from the manufacturing process. The main VOC emissions released from the site Acetone and Isopropanol.

1.2 Scope of the Survey

An emission monitoring survey was required to determine the release concentrations of various pollutants from the Inkjet manufacturing process vents. Concentrations of the following pollutants were quantified during the survey:

- Fluorine (F_2)
- Nickel (Ni)
- Lead (Pb) & Zirconium (Zr)
- Nitric acid (HNO_3)
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Sulphuric Acid (H_2SO_4)
- Target VOCs, in particular Acetone & Isopropanol
- Total VOCs expressed as Carbon (C)

Ancillary measurements of stack dimensions, temperature and velocity were also made.

Sampling for Total VOCs was carried out on a continuous basis with measured concentrations being data-logged at 1 minute intervals over each sampling period.

All results were to be reported at 273K, 101.3kPa, wet gas, without correction for oxygen content.

1.3 Sampling Personnel

Monitoring was conducted by the following REC Ltd permanent staff:-

- David Burns - Team Leader, MM05 579, MCERTS Level 2, TE1-4
- Michelle Edwards - Assistant, MM05 659, MCERTS Level 2, TE 1-3

2. METHODOLOGY

2.1 Species & Techniques

The following table shows the reference methods used for the emission monitoring survey:

Species	UKAS Status	Method	Uncertainty (±%)	Limit of Detection
Total VOCs (as C)	A	In house method MM0002 based on BS EN 12619	10	1 mg/m^3
Acetone	B	In house method MM0011 based on BS EN 13649	30	0.1 mg/m^3
Isopropyl Alcohol	B	In house method MM0011 based on BS EN 13649	30	0.1 mg/m^3
Hydrogen Chloride	E	Methodology based on NIOSH 7903	20	0.1 mg/m^3
Hydrogen Fluoride	E	Methodology based on NIOSH 7903	20	0.1 mg/m^3
Sulphuric Acid	E	Methodology based on NIOSH 7903	20	0.1 mg/m^3
Nitric Acid	E	Methodology based on NIOSH 7903	20	0.1 mg/m^3
Nickel	E	Methodology based on NIOSH 7900	20	0.01 mg/m^3
Lead	E	Methodology based on NIOSH 7900	20	0.01 mg/m^3
Zirconium	E	Methodology based on NIOSH 7900	20	0.01 mg/m^3
Fluorine	E	Methodology based on US EPA M26	20	0.1 mg/m^3

NOTE: UKAS Status:- (A) REC Ltd accredited for sampling and analysis. (B) REC Ltd accredited for sampling only, UKAS accredited analysis conducted by SAL Ltd. (C) REC Ltd accredited for sampling, sub-contracted analysis not UKAS accredited (D) REC Ltd not accredited for sampling, UKAS accredited analysis conducted by SAL Ltd. (E) REC Ltd not accredited for sampling, sub-contracted analysis not UKAS accredited.

2.2 Sampling & Analytical Methodology

Total VOCs

To determine the concentration of VOCs in emissions, a Bernath portable flame ionisation detector (FID) was employed. The analyser consists of a sintered filter, to remove particulate matter, a heated sampling line and heated FID block. This equipment satisfies the requirements of BS EN 12619 and in-house method MM0002 was followed.

The instrument is calibrated over a number of ranges against a traceable propane (C_3H_8) standard prior to and on completion of each test.

VOCs are detected by the FID with the output being proportional to the number of carbon atoms present in the sample. The readout displays a VOC figure expressed in ppm as carbon which is converted to mg/Nm^3 as carbon.

Target VOCs

Sampling for Isopropyl Alcohol and Acetone was carried out using charcoal adsorption tubes using methodology as per BS EN 13649 (in house method MM0011). The tubes were connected to calibrated low flow sampling pumps which have a set flow rate per stroke in millilitres per stroke. The actual volume sampled is calculated by multiplying the number of pump strokes by the calibration factor for the specific pump used.

The tubes were chemically desorbed and analysed by a high resolution GC/MS operating in the target mode to identify and quantify the compounds of interest against prepared standards. From the mass of each target VOC detected on the tube in microgram (µg/tube) and volume sampled, an emission concentration was calculated.

Acid Gases (HCl, HF, HNO_3 & H_2SO_4)

To determine the concentration of the above acids in emissions, sampling methodology based on the NIOSH Method 7903 was utilised.

A sample of the exhaust stream was removed from the stack via a PTFE probe and subsequently passed through a treated Silica gel tube. The tube was connected to a pump which was calibrated at a set flow rate of 0.5 l/min prior to and at the end of sampling.

Upon completion of sampling, the tube was capped, sealed and labelled before being stored in a cool box. The tube was subsequently analysed via an ion chromatographic (IC) technique.

Fluorine (USEPA 26A)

To determine the concentration of Fluorine (F_2) in emissions, sampling methodology based on US EPA Method 26A was utilised. A sample of the exhaust stream was removed from the stack via a PTFE probe and passed through a quartz fibre filter.

On leaving the filter, the sampled exhaust gas was passed into a series of Impingers. The first two contained dilute sodium hydroxide (0.1M NaOH) to absorb any F_2 present before passing through a dry gas meter (DGM) to measure the volume of gas sampled.

Upon completion of sampling, the contents of the first two Impingers were transferred to a sealed, labelled container, which was subsequently analysed for F_2 via an IC technique.

Nickel, Lead & Zirconium

Sampling for Nickel, Lead & Zirconium was conducted utilising methodology based on the Niosh method 7900.

A sample of the exhaust stream was extracted through a titanium probe and then passed through a quartz filter upon which any of the metals present would be collected. The sampling train was connected to a low flow pump which was set to a flow rate of 2 litres per minute.

Upon completion of sampling the filter was placed in to a petri dish, labelled and sent to the laboratory for analysis via ICP.

Stack Temperature and Velocity

To determine the stack temperature, a calibrated thermocouple and digital indicator were employed. The exhaust gas velocity was investigated using a pitot static probe (to MM0004) and digital manometer.

2.3 Laboratory Analysis

An approved UKAS accredited sub-contractor, SAL Ltd, undertook the sample analysis for the target VOCs (Acetone and Isopropanol), acid gases, Fluorine and heavy metals. Analysis for target VOCs, lead and nickel was covered under their scope of accreditation. Analysis for acid gases, fluorine and zirconium was not covered under their UKAS scope.

A copy of their Certificate of Analysis is enclosed in Appendix 1.

3. SAMPLING AND OPERATIONAL DETAILS

3.1 Process Description

The operations at Xaarjet Ltd are authorised under a Part B permit issued by the Local Authority under the Environmental Permitting Regulations, 2010. The process is therefore under Local Authority regulation and must demonstrate compliance with the emission limits stipulated in the site permit: B22/11.

The following Guidance Note applies:- PG6/45 (11)

The main emissions regulated under the permit are the VOC levels, with the additional testing being undertaken for internal information only.

The inkjet print head manufacturing process involves the utilisation of solvents, acids and plating solutions on a continuous basis in order to produce inks and print heads.

3.2 Sampling Positions

On LEV stacks 1 – 4, 1 x 12mm holes are located in a horizontal plane less than four hydraulic diameters downstream but greater than five hydraulic diameters upstream from potential flow disturbances. The flow criteria stipulated in the EA Technical Guidance Note M1 (EA TGN M1) was complied with in respect of the LEV stacks 1-4.

On LEV stacks, 7 & 8, 1 x 12mm holes are located in a vertical plane less than four hydraulic diameters downstream and upstream from potential flow disturbances. However, the gas flow criteria stipulated in EA TGN M1 was complied with.

On LEV stacks 9, 10, 17 & 18, 1 x 10mm holes are located in a vertical plane less than four hydraulic diameters downstream and upstream from potential flow disturbances. However, the gas flow criteria stipulated in EA TGN M1 was complied with.

On LEV stack 6, 1 x 12mm hole was installed in a horizontal plane greater than five hydraulic diameters downstream from any flow disturbances but less than four hydraulic diameters upstream from a bend. The flow criteria stipulated in EA TGN M1 was however complied with.

On LEV stacks 14, 1 x 25mm holes are located in a horizontal plane positioned less than five hydraulic diameters downstream from potential flow disturbances but greater than five hydraulic diameters upstream from potential flow disturbances. The flow criteria stipulated in EA TGN M1 was however complied with.

On LEV stack 13, 1 x 25mm hole is installed in a horizontal plane. The sampling plane is located less than five hydraulic diameters downstream from and less than two hydraulic diameters upstream from potential flow disturbances. The flow criteria stipulated in EA TGN M1 was however complied with.

On Lev stacks 15 & 19, 1 x 10 mm hole was installed in a horizontal plane which was located 5 hydraulic diameters from potential flow disturbances both upstream and downstream. The Velocity and temperature traverse carried out on both stacks was compliant with the flow criteria stipulated in the EA TGN M1 document.
Diagrams detailing the sampling positions and taken from Site Worksheets are provided in Appendix 2.

3.3 Uncertainty

As the pollutants are present in the gaseous phase and assumed to be homogenous across the sampling plane the standard uncertainties would apply in respect of the Total VOC and Target VOC test results.

The uncertainty values for the remaining pollutants are based on values stated in NIOSH methods. These have been included for reference purposes but lie outside the scope of RECs accreditation.

REC has calculated uncertainty budgets for the pollutants listed in the Method Details Table in Section 2.1 above, for which we are UKAS accredited, in accordance with calculations and methodology supplied by the Source Testing Association (STA). These uncertainties are quoted in the Tables section of this report.

3.4 Emission Monitoring Survey Details

The emission monitoring survey was carried out on the Inkjet manufacturing process vents over the period 7-9 April, 2014. The table overleaf summarises the actual sampling periods.

SAMPLING PERIODS

Stack Ref.	Parameter	Sample Time (& Date)
LEV 1	Total VOCs	10:10 – 11:10 (9/4/14)
	Target VOCs	8:54-10:03 (9/4/14)
LEV 2	Total VOCs	9:07-10:07 (9/4/14)
	Target VOCs	10:06-11:06 (9/4/14)
LEV 3	Fluorine	9:21-10:21(9/4/14)
LEV 4	Fluorine	8:45-9:45 (9/4/14)
LEV 6	HNO_3, HF / HCl /H_2SO_4	14:48-15:49 (7/4/14)
	Nickel	9:25-10:25 (8/4/14)
LEV 7	HNO_3	11:36 – 12:36 (7/4/14)
LEV 8	Lead & Zirconium	11:56-12:56 (7/4/14)
LEV 9	Total VOCs	12:48 -13:48 (7/4/14)
	Target VOCs	12:48 -13:48 (7/4/14)
LEV 10	Lead & Zirconium	10:22-11:22 (8/4/14)
LEV 13	Total VOCs	9:40-10:40 (8/4/14)
	Target VOCs	9:40-10:40 (8/4/14)
LEV 14	Total VOCs	12:42-13:42 (8/4/14)
	Target VOCs	12:42-13:42 (8/4/14)
LEV 15	Nitric acid	14:49 -15:51 (8/4/14)
LEV 17	Total VOCs	11:12-12:12 (8/4/14)
	Target VOCs	10:14-11:14 (8/4/14)
LEV 18	Lead & Zirconium	15:02 – 16:02 (7/4/14)
LEV 19	Total VOCs	13:55-14:55 (7/4/14)
	Target VOCs	11:20-12:20 (7/4/14)

4. RESULTS AND DISCUSSION

4.1 Initial Velocity and Temperature Traverse

An initial pitot-static pressure and temperature traverse was carried out. From these data stack velocity, expressed in metres per second (m/s), and volumetric flowrates expressed in cubic metre per hour (m^3/hr) have been calculated.

The results are reported at actual stack conditions and the volumetric flowrate is further expressed at the standard reference conditions of 273K, 101.3kPa i.e. standard temperature and pressure (STP). The results are summarised in Table 1.

4.2 Total VOCs Emission data

The results of the VOC monitoring tests are summarised in Table 2 and Figures 1 to 7. The table presents the average of concentrations measured throughout each of the sample periods.

Concentrations are expressed in mg/m^3 as carbon (C) at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour and O_2 content.

4.3 Target VOC Emission Data

The results of the VOC monitoring using adsorption tubes are summarised in Table 3

From the mass of each VOC detected on each tube in microgram (µg/tube), and the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

4.4 Fluorine Emission Data

The results of the Fluorine sampling runs are summarised in Table 4.

From the concentration of Fluorine in the absorbing solution, and the measured volume of absorbing solution, a total mass of Fluorine in microgram (g) was determined. From the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

4.5 Acid Gas Emission Data

The results of the acid gas emissions tests are summarised in Table 5.

From the mass of each respective acid gas detected on each tube in microgram, and the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

4.6 Nickel Emission Data

The results of the Nickel emissions tests are summarised in Table 6.

From the mass of Nickel measured on the filter in microgram and the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

4.7 Lead & Zirconium Emission Data

The results of the Lead & Zirconium emissions tests are summarised in Table 7.

From the mass of Pb and Zr on the filter in microgram and the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

====== End of Report Text ======

FIGURES

Fig 1: Total VOC Emission Data, Xaar Jet, LEV 1, (09/04/14)

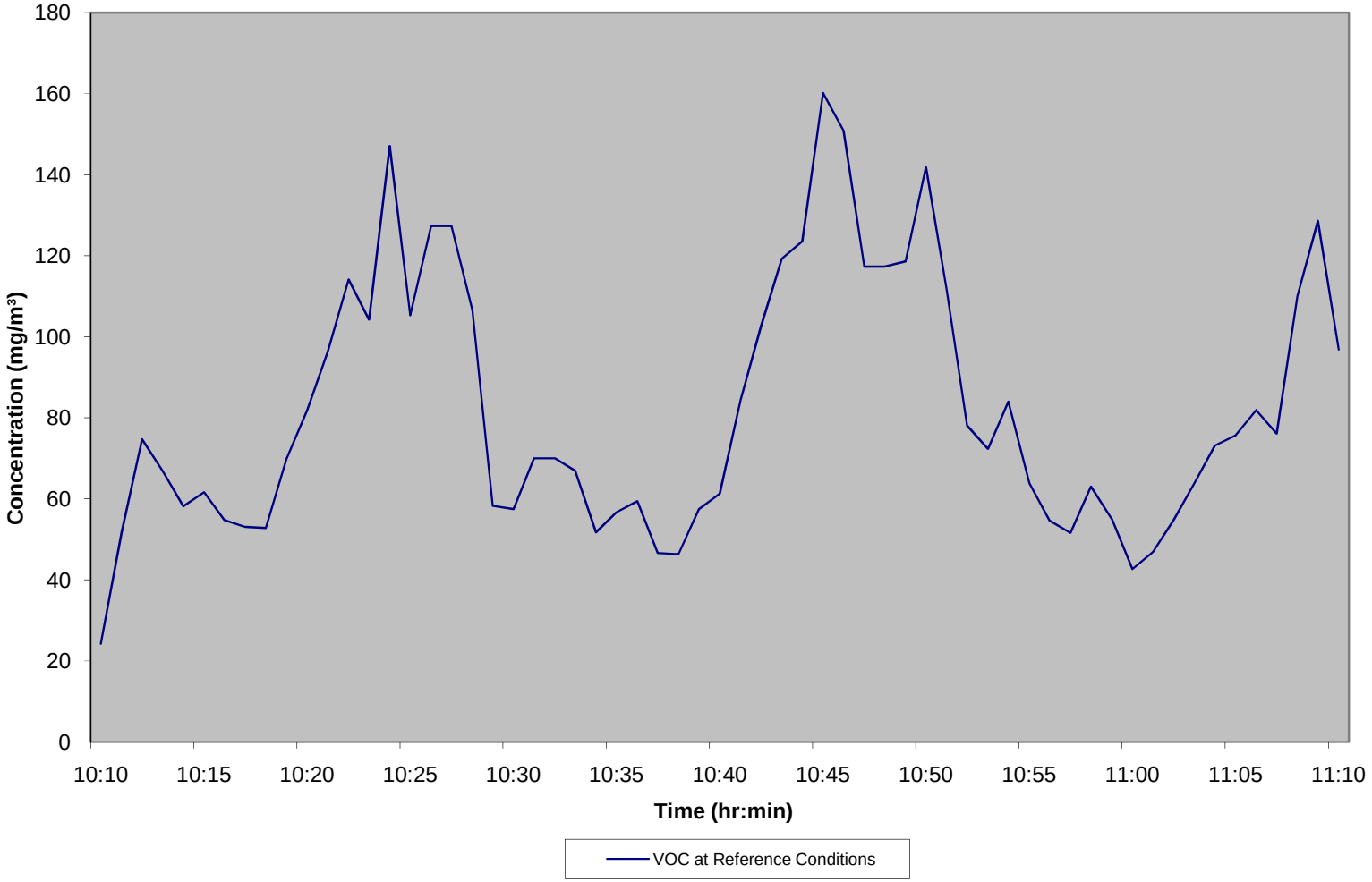


Fig 2: Total VOC Emission Data, Xaar Jet, LEV 2, (09/04/14)

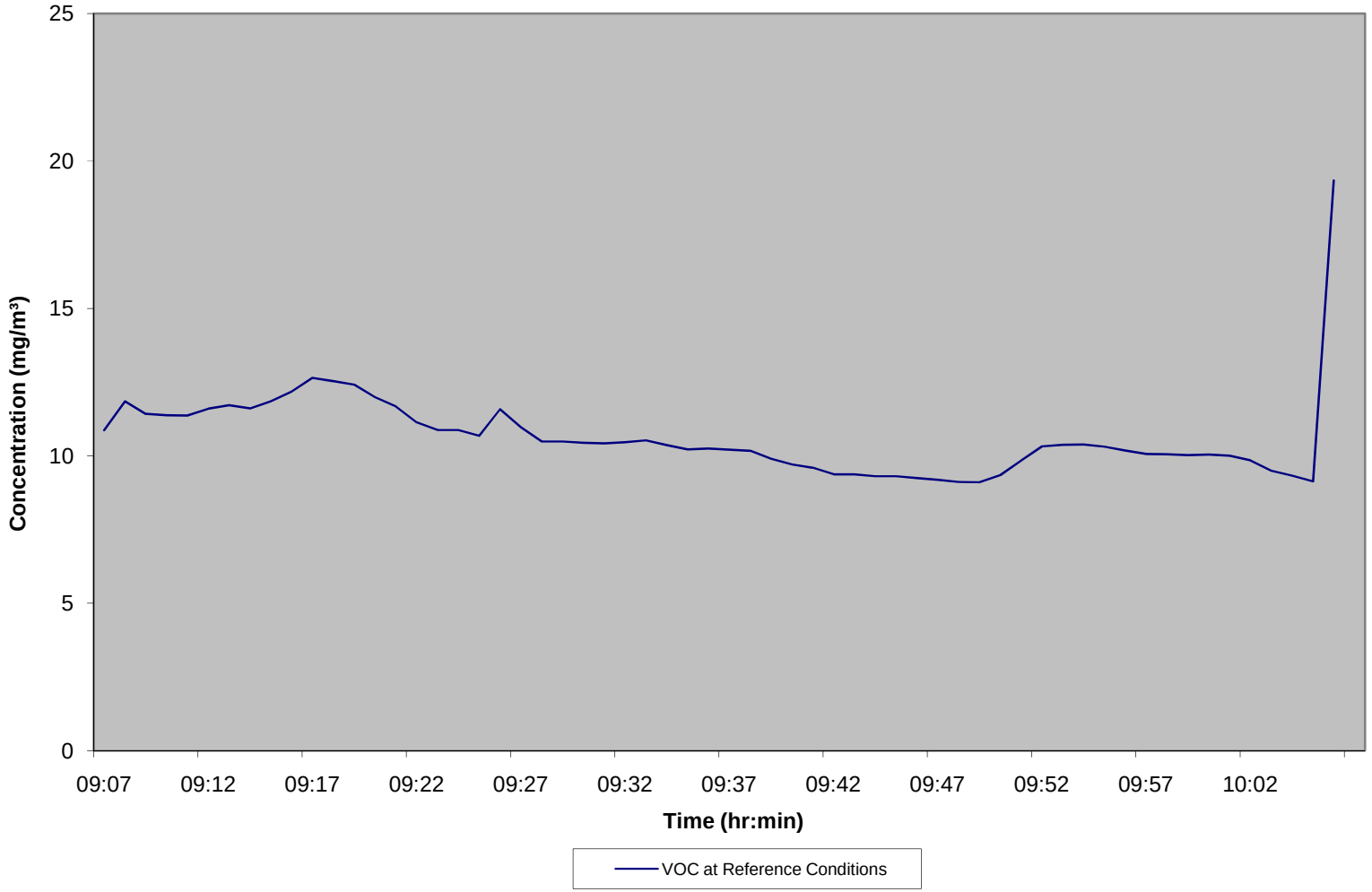


Fig 3: Total VOC Emission Data, Xaar Jet, LEV 9, (07/04/14)

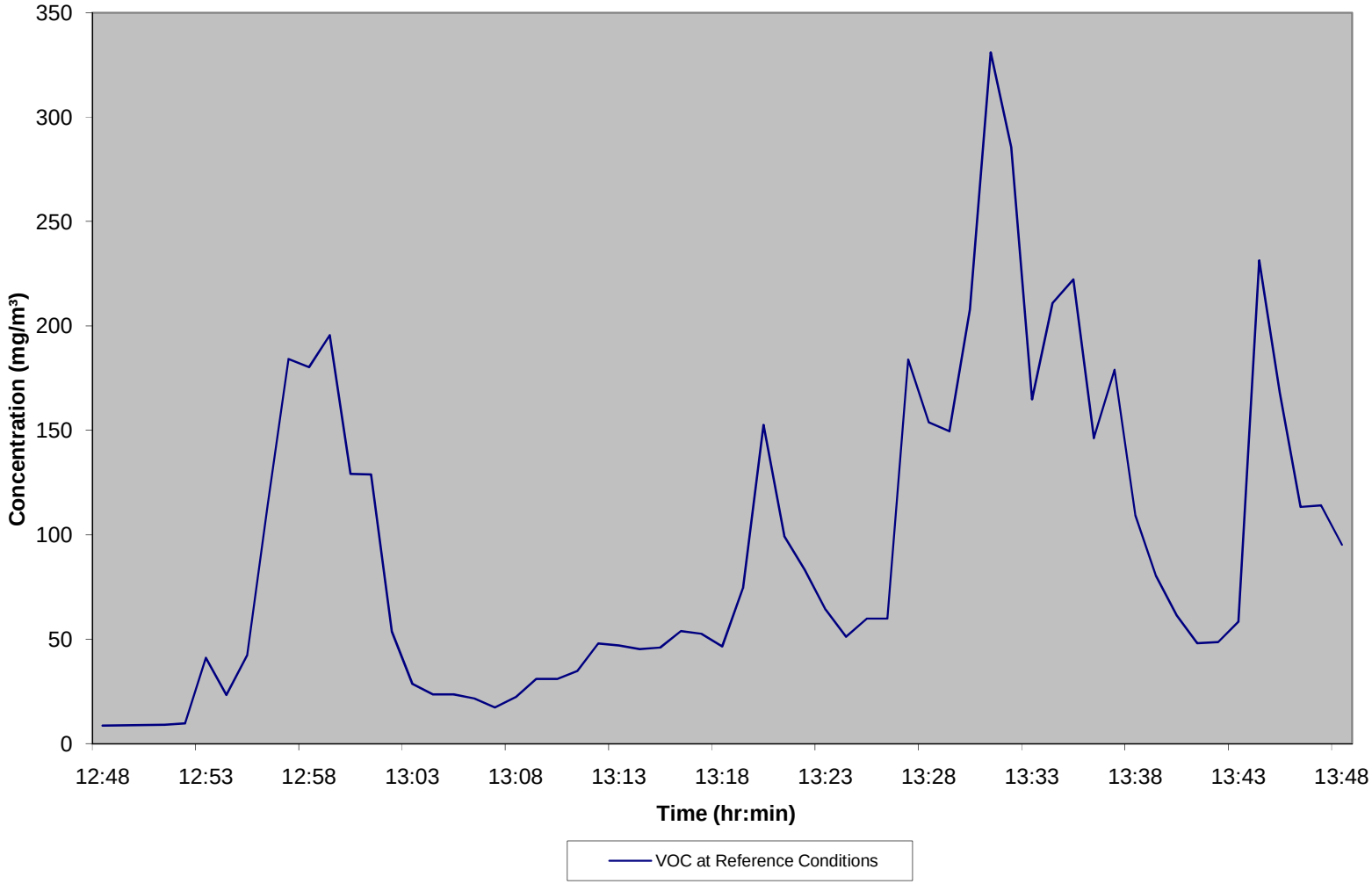


Fig 4: Total VOC Emission Data, Xaar Jet, LEV 13, (08/04/14)

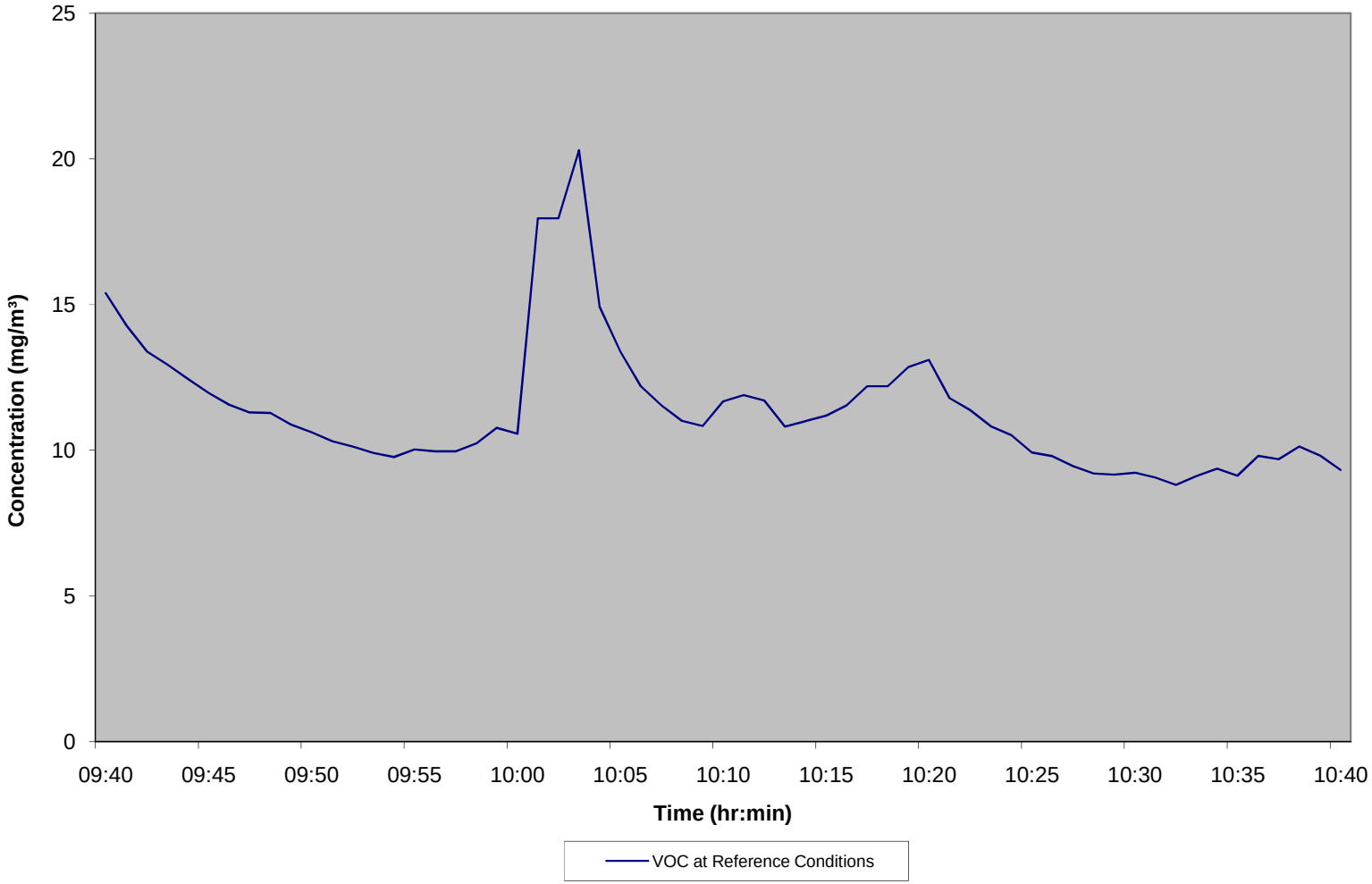


Fig 5: Total VOC Emission Data, Xaar Jet, LEV 14, (08/04/14)

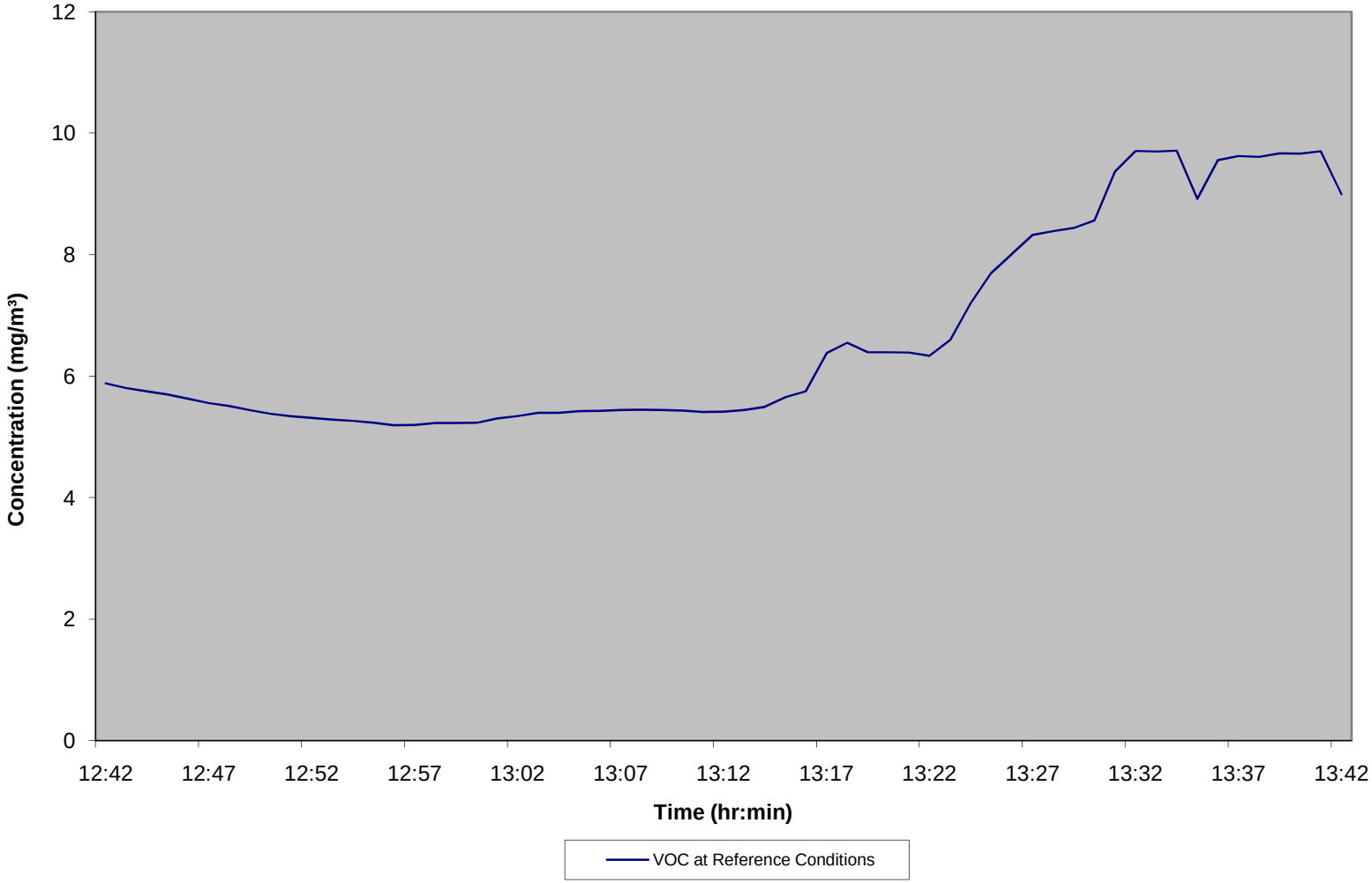


Fig 6: Total VOC Emission Data, Xaar Jet, LEV 17, (08/04/14)

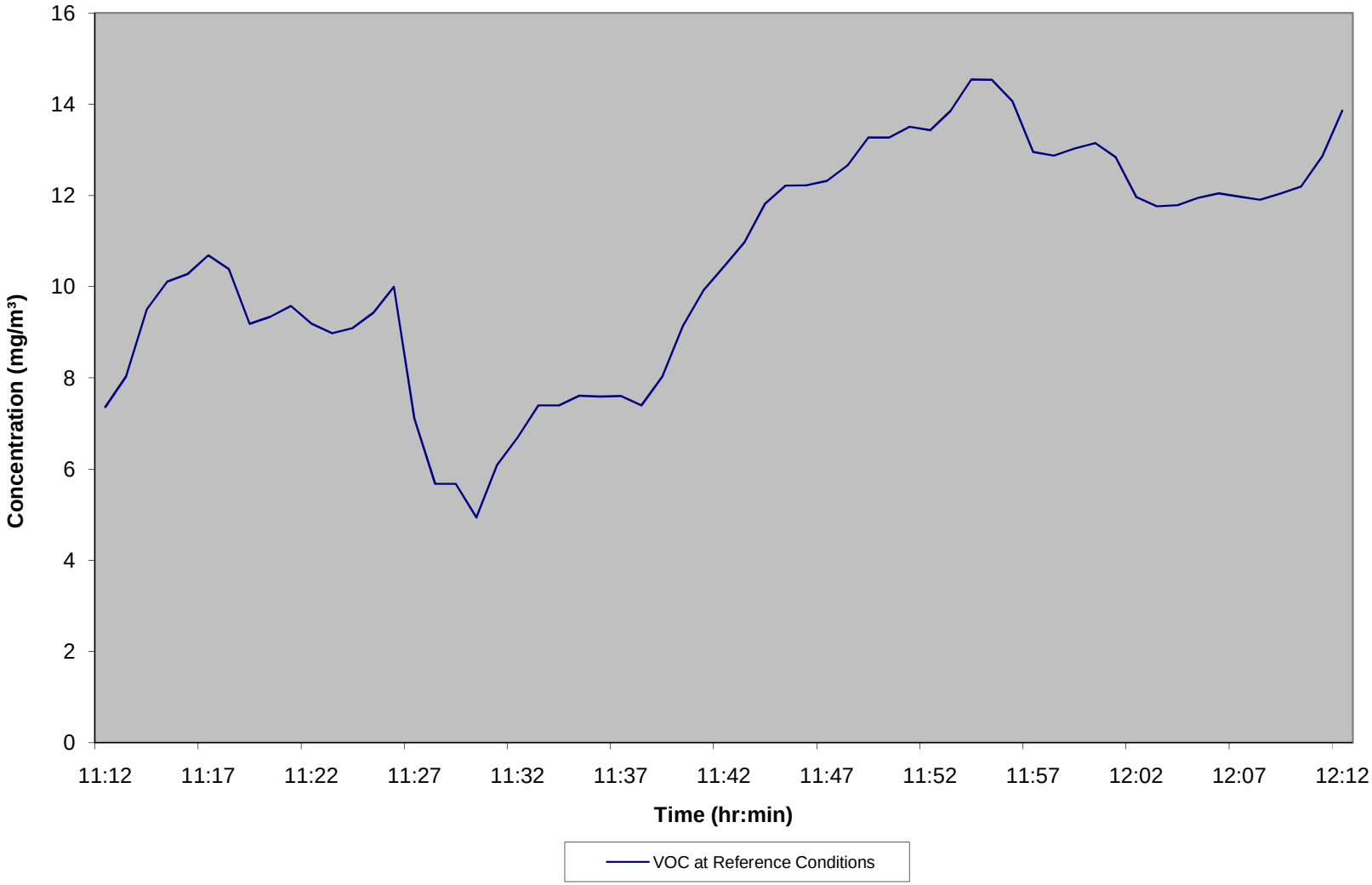
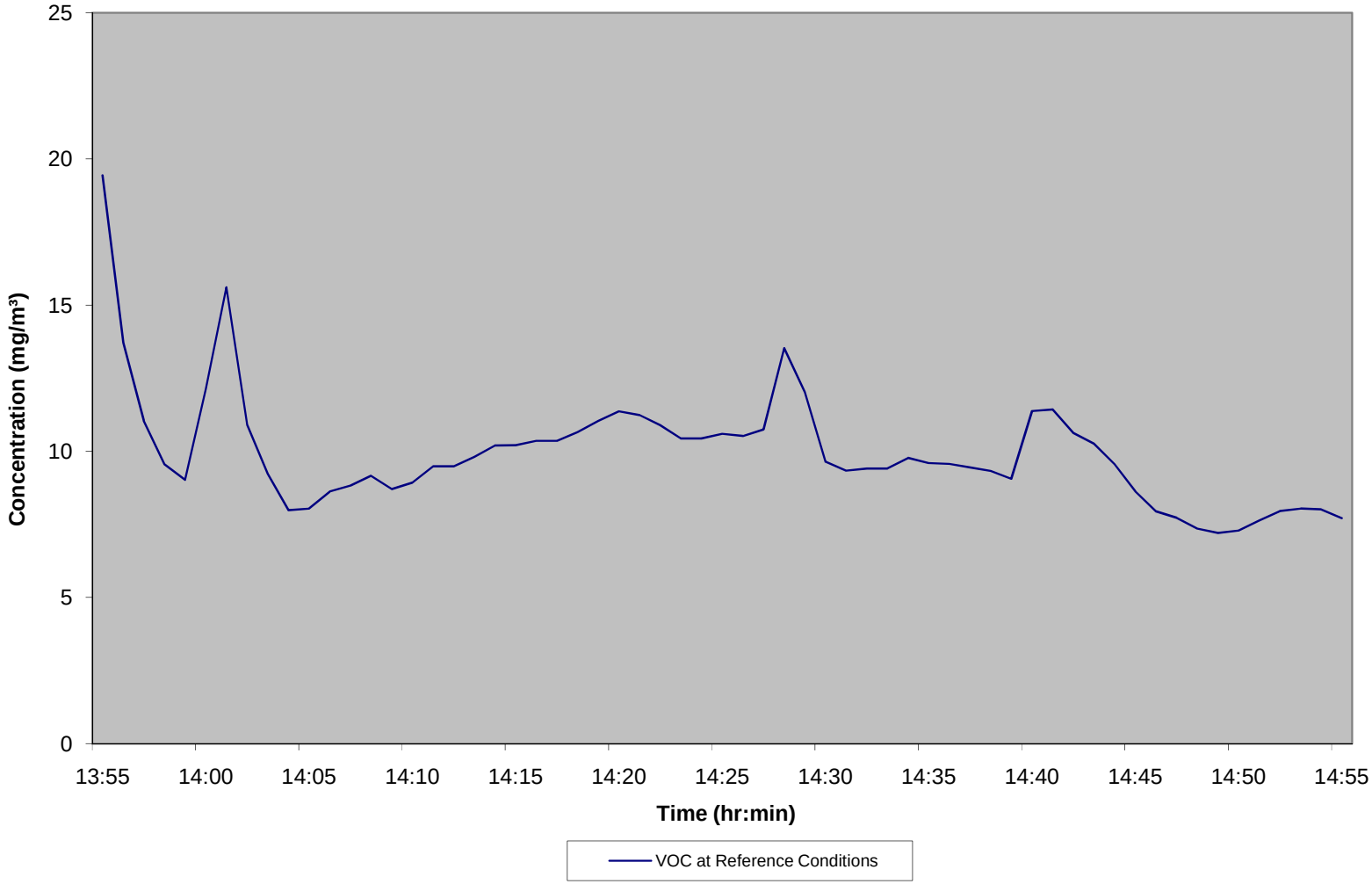


Fig 7: Total VOC Emission Data, Xaar Jet, LEV 19, (07/04/14)



TABLES

TABLE 1

FLOW DATA

Stack Ref.	Stack Temp	Av Pitot ΔP	Duct Diam	X-Sect. Area	Velocity (actual)	Volume Flow (m^3/hr)	
	(^{0}C)	(Pa)	(cm)	(m^2)	(m/s)	(actual)	(@ ntp)
LEV 1	17	33	40	0.126	7.3	3,311	3,119
LEV 2	18	32	30.5	0.073	7.2	1,901	1,785
LEV 3	21	11	40	0.126	4.3	1,957	1,818
LEV 4	14	45	31	0.075	8.5	2,309	2,193
LEV 6	19	31	45	0.159	7.2	4,094	3,824
LEV 7	17	45	30	0.071	8.6	2,192	2,065
LEV 8	15	12	31.5	0.078	4.4	1,225	1,158
LEV 9	18	48	30	0.071	8.9	2,270	2,129
LEV 10	18	13	45	0.159	4.7	2,671	2,509
LEV 13	24	48	60	0.283	9.0	9,206	8,457
LEV 14	21	13	45	0.159	4.6	2,654	2,461
LEV 15	20	10	25	0.049	4.1	717	670
LEV 17	16	30	9	0.006	7.1	162	153
LEV 18	16	18	35	0.096	5.5	1,891	1,786
LEV 19	17	35	35	0.096	7.7	2,651	2,498

TABLE 2

TOTAL VOC EMISSION DATA SUMMARY –

Stack Ref	Total VOCs	
	ppm (as C_3H_8)	mg/m^3 (as C)
LEV 1	51.0	82.0
Uncertainty (±)		3.0
LEV 2	6.6	10.6
Uncertainty (±)		2.5
LEV 9	58.3	93.8
Uncertainty (±)		3.3
LEV 13	7.1	11.4
Uncertainty (±)		2.6
LEV 14	4.1	6.7
Uncertainty (±)		2.6
LEV 17	6.5	10.5
Uncertainty (±)		2.6
LEV 19	6.2	10.0
Uncertainty (±)		2.6

TABLE 3
ACETONE & ISOPROPYL ALCOHOL EMISSION DATA – LEVs 1, 2, 9 ,13, 14, 17 & 19.

Sampling Data	**LEV 1**	**LEV 2**	**LEV 9**	**LEV 13**	**LEV 14**	**LEV 17**	**LEV 19**
Pump Ref (AQ No.)	205	205	205	205	205	205	205
Start Time	08:54	10:06	12:48	09:40	12:42	10:14	11:20
End Time	10:03	11:06	13:48	10:40	13:42	11:14	12:20
Counter Start	23233	43995	29424	52015	5269	987198	968845
Counter End	43953	61922	51924	73843	23189	1005263	987198
Calibration Factor	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Volume Sampled (litres)	9.738	8.426	10.575	10.259	8.422	8.491	8.626
Ambient Temp (^{o}C)	5.6	5.6	16.1	18.1	18.1	18.1	16.9
Ambient Press (kPa)	102	102	100	100.9	100.9	100.9	100.1
Volume Sampled, 273K, 101.3kPa (litres)	9.609	8.313	9.858	9.583	7.868	7.931	8.027
Analytical Data	**71836/14**	**71836/15**	**71836/3**	**71836/10**	**71836/13**	**71836/11**	**71836/2**
Mass Acetone on tube front section (µg)	26	22	530	140	31	35	14
Mass Acetone on tube rear section (µg)	<10	<10	<10	<10	<10	<10	<10
Mass on Back-up Section (%)	<5	<5	<5	<5	<5	<5	<5
Mass Isopropyl on tube front section (µg)	280.0	13.0	600.0	19.0	15.0	32.0	<10.0
Mass Isopropyl on tube rear section (µg)	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Mass on Back-up Section (%)	<5	<5	<5	<5	<5	<5	<5
Emission Concentration Data							
Acetone(mg/m^{3})	3.7	3.8	54.8	15.7	5.2	5.7	3.0
Uncertainty (± mg/m^{3})	1.1	1.2	16.5	4.7	1.6	1.7	0.9
Isopropyl alcohol (mg/m^{3})	30.2	2.8	61.9	3.0	3.2	5.3	<2.5
Uncertainty (± mg/m^{3})	9.1	0.8	18.7	0.9	1.0	1.6	0.8

TABLE 4

FLUORINE EMISSION DATA SUMMARY - LEVs 3 & 4

Sampling Data	LEV 3	LEV 4
Start Time/Date	09:21, 09/04/14	08:45, 09/04/14
End Time/Date	10:21, 09/04/14	09:46, 09/09/09
Sampling Period (min)	60	61
DGM start (dry m^3)	56.681	63.799
DGM end (dry m^3)	56.818	63.968
Volume Sampled (dry m^3)	0.137	0.169
Ambient Temp (^oC)	5.6	5.6
Ambient Press (kPa)	102	102
Wt of Water (g)	7.5	13.5
Volume Water (m^3)	0.009	0.017
Volume Sampled, 273K, 101.3kPa (dry m^3)	0.135	0.167
Volume Sampled, 273K, 101.3kPa (wet m^3)	0.144	0.184
Volume 0.1 M NAOH Impingers (ml)	180	230
Analytical Data		
F in H_2SO_4 Blank (mg/l)	<0.05	<0.05
F in H_2SO_4 Imps (mg/l)	<0.05	<0.05
F in H_2SO_4 (µg)	<9	<12
Emission Concentration Data		
Moisture (%vol)	6.5	9.2
F_2 (mg/m^3)	<0.1	<0.1

TABLE 5

ACID GAS EMISSION DATA SUMMARY - LEVs 6, 7 ,15 & 19.

Sampling Data	**LEV 6**	**LEV 7**	**LEV 15**	**LEV 19**
Pump Ref (AQ No.)	363	363	363	363
Start Time	14:49	11:36	14:49	12:42
End Time	15:49	12:36	15:49	13:42
Start Flowrate (l/min)	0.5	0.5	0.5	0.5
Endt Flowrate (l/min)	0.5	0.5	0.5	0.5
Sampling Duration in minutes	60	60.00	60	60.00
Volume Sampled (litres)	30.000	30.000	30.000	30.000
Ambient Temp (^{o}C)	16.8	16.1	18.1	16.1
Ambient Press (kPa)	100	100.1	100.9	100.1
Volume Sampled, 273K, 101.3kPa (litres)	27.898	27.994	28.024	27.994
Analytical Data	**71836/6**	**71836/1**	**71836/9**	**71836/5**
Mass HCL on tube (µg)	0.8	-		-
Mass HN03 tube (µg)	36	1.7	<0.4	0.2
Mass H2S04 on tube (µg)	<2	-		-
Mass HF on tube (µg)	<0.4	-		-
Emission Concentration Data				
HF (mg/m^3)	<0.01	-	-	-
HCL (mg/m^3)	0.03	-	-	-
H_2SO_4 (mg/m^3)	<0.07	-	-	-
HNO_3 (mg/m^3)	1.3	0.06	<0.01	0.01
Uncertainty (± mg/m^3)	0.4	0.0	0.0	0.0

TABLE 6

NICKEL EMISSION DATA SUMMARY - LEV 6

Sampling Data	**LEV 6**
Pump Ref (AQ No.)	337
Start Time	09:25
End Time	10:25
Start DGM	63.622
END DGM	63.796
Volume Sampled (litres)	174.000
Ambient Temp (^{o}C)	16
Ambient Press (kPa)	100.7
Volume Sampled, 273K, 101.3kPa (litres)	163.393
Analytical Data	**71490/8**
Mass Nickel (μg)	<1
Emission Concentration Data	
Nickel (mg/m^{3})	<0.01
Uncertainty (± mg/m^{3})	0.01

TABLE 7

LEAD & ZIRCONIUM EMISSION DATA SUMMARY - LEV 8, 10 & 18

Sampling Data	**LEV 8**	**LEV 10**	**LEV 18**
Pump Ref (AQ No.)	337	337	337
Start Time	11:56	10:22	15:02
End Time	12:56	11:22	16:02
Start DGM	63.323	56.5318	63.467
End DGM	63.466	56.6892	63.621
Volume Sampled (litres)	143.000	157.400	154.000
Ambient Temp (^{o}C)	16	17	17
Ambient Press (kPa)	100.1	100	100.1
Volume Sampled, 273K, 101.3kPa (litres)	133.483	146.272	143.255
Analytical Data	**71836/4**	**71836/12**	**71836/7**
Mass Lead (µg)	<1	<1	1
Mass Zirconium (µg)	<1	<1	<1
Emission Concentration Data			
Zirconium (mg/m^3)	<0.01	<0.01	<0.01
Lead (mg/m^3)	<0.01	<0.01	0.01
Uncertainty (± mg/m^3)	0.01	0.01	0.01

APPENDIX 1

Certificate of Analysis

Scientific Analysis Laboratories is a
limited company registered in England and
Wales (No 2514788) whose address is at
Hadfield House, Hadfield Street, Manchester M16 9FE

Scientific Analysis Laboratories Ltd

Certificate of Analysis

Hadfield House
Hadfield Street
Cornbrook
Manchester
M16 9FE
Tel : 0161 874 2400
Fax : 0161 874 2404

Report Number: 388135-1

Date of Report: 22-Apr-2014

Customer: Resource Environmental Consultants Ltd
Unit 19
Bordesley Trading Estate
Bordesley Green Road
Birmingham
B8 1BZ

Customer Contact: Ms Michelle Edwards

Customer Job Reference: 71836
Customer Site Reference: Date Collected: 7/4/14 - 9/4/14
Date Job Received at SAL: 10-Apr-2014
Date Analysis Started: 17-Apr-2014
Date Analysis Completed: 22-Apr-2014

The results reported relate to samples received in the laboratory
Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

Tests covered by this certificate were conducted in accordance with SAL SOPs
All results have been reviewed in accordance with QP22

UKAS TESTING
1549

Report checked
and authorised by :
James Allan
Project Manager

Issued by :
James Allan
Project Manager

Signature valid
Digitally signed by James Allan
Date: 2014.04.22 17:45:04 BST
Reason: Issue
Location: SAL

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Impinger (sodium hydroxide) Analysed as Impinger (sodium hydroxide)
Miscellaneous

				SAL Reference	**388135 027**	**388135 028**	**388135 035**
				Customer Sample Reference	**71836/16**	**71836/17**	**71836/21**
				Test Sample	**AR**	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Fluoride	IC	0.05	mg/l	U	(13) <0.05	(13) <0.05	(13) <0.05
Volume	Vol	1	ml	U	**180**	**230**	**180**

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Filter Analysed as Filter
Miscellaneous

				SAL Reference	**388135 013**	**388135 037**
				Customer Sample Reference	**71836/8**	**71836/23**
				Test Sample	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Nickel	ICP/OES	1	µg	U	<1	<1

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Silica Gel) Analysed as Tube (Silica Gel)
Miscellaneous

				SAL Reference	**388135 001**	**388135 002**	**388135 008**	**388135 009**	**388135 010**
				Customer Sample Reference	**71836/1 FRONT**	**71836/1 BACK**	**71836/5 FRONT**	**71836/5 BACK**	**71836/6 FRONT**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Nitric Acid	IC	0.2	µg	N	**(13) 0.9**	**(13) 0.8**	(13) <0.2	**(13) 0.2**	**(13) 21**

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Silica Gel) Analysed as Tube (Silica Gel)
Miscellaneous

				SAL Reference	**388135 011**	**388135 014**	**388135 015**	**388135 031**	**388135 032**
				Customer Sample Reference	**71836/6 BACK**	**71836/9 FRONT**	**71836/9 BACK**	**71836/19 FRONT**	**71836/19 BACK**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Nitric Acid	IC	0.2	µg	N	**(13) 15**	(13) <0.2	(13) <0.2	(13) <0.2	(13) <0.2

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Silica Gel) Analysed as Tube (Silica Gel)
Miscellaneous

				SAL Reference	**388135 033**	**388135 034**
				Customer Sample Reference	**71836/20 FRONT**	**71836/20 BACK**
				Test Sample	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Nitric Acid	IC	0.2	µg	N	(13) <0.2	(13) <0.2

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Filter Analysed as Filter
Filter suite 2

	SAL Reference	388135 007	388135 012	388135 020	388135 036
	Customer Sample Reference	71836/4	71836/7	71836/12	71836/22
	Test Sample	AR	AR	AR	AR
Determinand	**Method** / **LOD** / **Units** / **Symbol**				
Lead	ICP/OES / 1 / µg / U	<1	**1**	<1	<1
Zinc	ICP/OES / 1 / µg / U	<1	<1	<1	<1

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Silica Gel) Analysed as Tube (Silica Gel)
Suite A

	SAL Reference	388135 001	388135 002	388135 008	388135 009	388135 010
	Customer Sample Reference	71836/1 FRONT	71836/1 BACK	71836/5 FRONT	71836/5 BACK	71836/6 FRONT
	Test Sample	AR	AR	AR	AR	AR
Determinand	**Method** / **LOD** / **Units** / **Symbol**					
Hydrogen Chloride	IC / 0.2 / µg / N	-	-	-	-	(13) **0.3**
Hydrogen Fluoride	IC / 0.2 / µg / N	-	-	-	-	(13) <0.2
Nitric Acid	IC / 0.2 / µg / N	(13) **0.9**	(13) **0.8**	(13) <0.2	(13) **0.2**	(13) **21**
Sulphuric acid	IC / 1.0 / µg / N	-	-	-	-	(13) <1.0

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Silica Gel) Analysed as Tube (Silica Gel)
Suite A

	SAL Reference	388135 011	388135 014	388135 015	388135 031	388135 032
	Customer Sample Reference	71836/6 BACK	71836/9 FRONT	71836/9 BACK	71836/19 FRONT	71836/19 BACK
	Test Sample	AR	AR	AR	AR	AR
Determinand	**Method** / **LOD** / **Units** / **Symbol**					
Hydrogen Chloride	IC / 0.2 / µg / N	(13) **0.5**	-	-	(13) <0.2	(13) <0.2
Hydrogen Fluoride	IC / 0.2 / µg / N	(13) <0.2	-	-	(13) <0.2	(13) <0.2
Nitric Acid	IC / 0.2 / µg / N	(13) **15**	(13) <0.2	(13) <0.2	(13) <0.2	(13) <0.2
Sulphuric acid	IC / 1.0 / µg / N	(13) <1.0	-	-	(13) <1.0	(13) <1.0

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Silica Gel) Analysed as Tube (Silica Gel)
Suite A

	SAL Reference	388135 033	388135 034
	Customer Sample Reference	71836/20 FRONT	71836/20 BACK
	Test Sample	AR	AR
Determinand	**Method** / **LOD** / **Units** / **Symbol**		
Hydrogen Chloride	IC / 0.2 / µg / N	-	-
Hydrogen Fluoride	IC / 0.2 / µg / N	-	-
Nitric Acid	IC / 0.2 / µg / N	(13) <0.2	(13) <0.2
Sulphuric acid	IC / 1.0 / µg / N	-	-

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Suite A

				SAL Reference	**388135 003**	**388135 004**	**388135 005**	**388135 006**	**388135 016**
				Customer Sample Reference	**71836/2 FRONT**	**71836/2 BACK**	**71836/3 FRONT**	**71836/3 BACK**	**71836/10 FRONT**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Acetone	GC/MS	10	µg	U	**14**	<10	**(195) 530**	<10	**140**
Propan-2-ol	GC/MS	10	µg	U	<10	<10	**(195) 600**	<10	**19**

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Suite A

				SAL Reference	**388135 017**	**388135 018**	**388135 019**	**388135 021**	**388135 022**
				Customer Sample Reference	**71836/10 BACK**	**71836/11 FRONT**	**71836/11 BACK**	**71836/13 FRONT**	**71836/13 BACK**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Acetone	GC/MS	10	µg	U	<10	**35**	<10	**31**	<10
Propan-2-ol	GC/MS	10	µg	U	<10	**32**	<10	**15**	<10

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Suite A

				SAL Reference	**388135 023**	**388135 024**	**388135 025**	**388135 026**	**388135 029**
				Customer Sample Reference	**71836/14 FRONT**	**71836/14 BACK**	**71836/15 FRONT**	**71836/15 BACK**	**71836/18 FRONT**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Acetone	GC/MS	10	µg	U	**26**	<10	**22**	<10	<10
Propan-2-ol	GC/MS	10	µg	U	**280**	<10	**13**	<10	<10

SAL Reference: 388135
Project Site: Date Collected: 7/4/14 - 9/4/14
Customer Reference: 71836

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Suite A

				SAL Reference	**388135 030**
				Customer Sample Reference	**71836/18 BACK**
				Test Sample	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**	
Acetone	GC/MS	10	µg	U	<10
Propan-2-ol	GC/MS	10	µg	U	<10

Index to symbols used in 388135-1

Value	Description
AR	As Received
195	Due to levels found in the sample that are outside of the normal calibration range of the instrument, analysis was conducted on a diluted sample
13	Results have been blank corrected.
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited

APPENDIX 2

Diagrams of Sampling Points

LEVs 1 -4

LEVs 5 – 8

LEV 14

LEV 6

LEVs 10, 11 & 13

APPENDIX 3

Calculations

Conversion Factors

ppm ® mg/Nm³ (at 273K, 101.3kPa: STP)

CO	x	1.25	
SO_2	x	2.86	
VOC's	x	1.61	(ppm as C_3H_8 to mg/Nm^3 as C)
NO_X	x	2.05	(ppm NO + NO_2 to mg/m^3 as NO_2)

Oxygen Correction to Reference Value

Concentration at (STP) -> Concentration at 273K, 101.3kPa, reference O_2 and Dry Gas, i.e.

Concentration X ((20.9-O_2 ref)/(20.9-O_2 measured)) = Concentration at ref Oxygen state.

Example Calculation

SO_2 concentration at STP	=	170.7 mg/Nm³
Oxygen percentage in gas stream	=	13.8%
Reference Oxygen	=	11%

SO_2 concentration at reference O_2 conditions	=	170.7 ((20.9-11)/(20.9-13.8))
	=	238 mg/Nm³ at 273K, 101.3kPa, 11% O_2 and Dry Gas

Moisture Correction (Wet to Dry)

Concentration of Gas Dry = Concentration of x 100/100-Bws Gas Wet

Concentration of Gas Wet = Concentration of x 100-Bws/100 Gas Dry

Where Bws = moisture content of gas stream in percent (Vol/Vol).

Example

VOC concentration	=	25 mg/Nm³ (Wet)
Moisture Content	=	27.1%
Concentration of VOC	=	25 (100/(100-27.1))

Carbon (C) to Trichloethylene (TCE)

ppm TCE = ppm C x 0.6715

TCE in mg/m^3 = TCE ppm x 5.864 (Mol Wt/22.4)